CHAPTER 1 - BASIC TERMS AND CALCULATIONS

1.1 Introduction to surface area
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1.1 Introduction to surface area

1.1.1 Triangles
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1.1.4 Trapeziums
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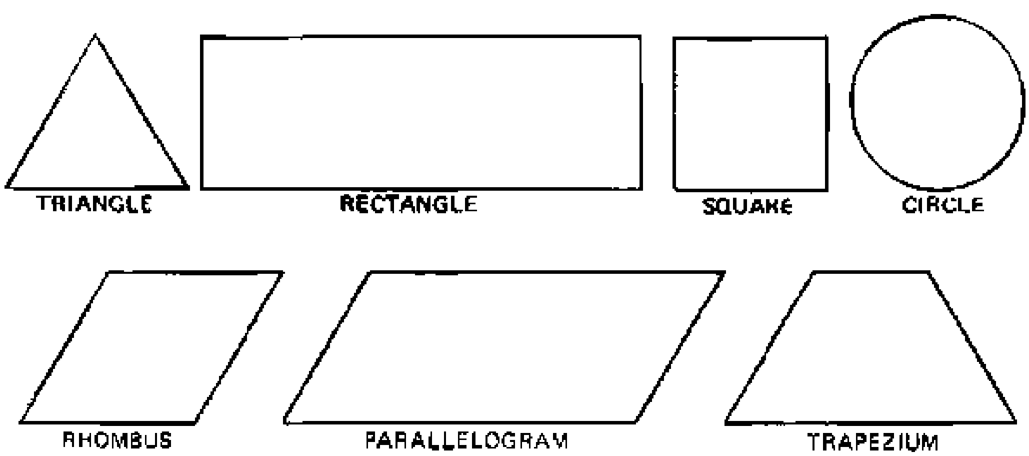
1.1.6 Metric Conversions

It is important to be able to measure and calculate surface areas. It might be necessary to calculate, for example, the surface area of the cross-section of a canal or the surface area of a farm.

This Section will discuss the calculation of some of the most common surface areas: the triangle, the square, the rectangle, the rhombus, the parallelogram, the trapezium and the circle (see Fig. 1a).

Fig. 1a. The most common surface areas

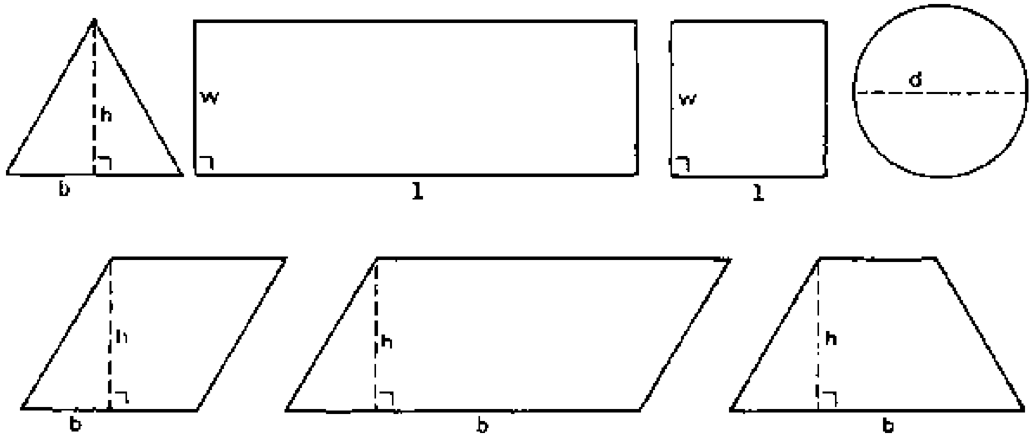


The height (h) of a triangle, a rhombus, a parallelogram or a trapezium, is the distance from a top corner to the opposite side called base (b). The height is always perpendicular to the base; in other words, the height makes a "right angle" with the base. An example of a right angle is the corner of this page.

In the case of a square or a rectangle, the expression length (1) is commonly used instead of base and width (w) instead of height. In the case of a circle the expression diametre (d) is used (see Fig. 1b).

Fig. 1b. The height (h), base (b), width (w), length (1) and diametre (d) of the most common

surface areas



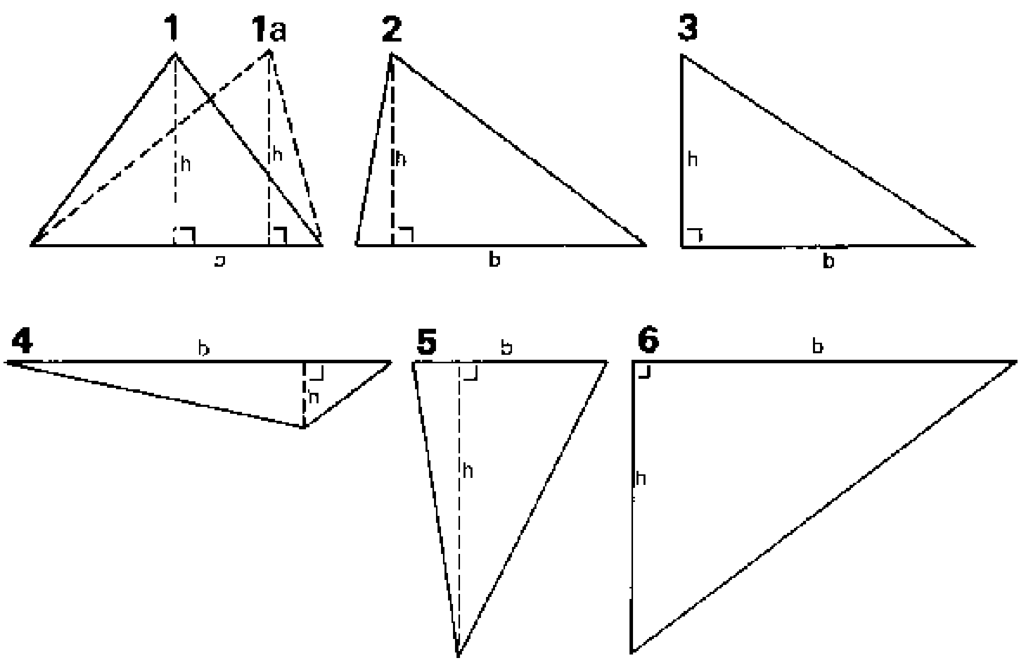
1.1.1 Triangles

The surface area or surface (A) of a triangle is calculated by the formula:

A (triangle) = 0.5 x base x height = 0.5 x b x h ..... (1)

Triangles can have many shapes (see Fig. 2) but the same formula is used for all of them.

Fig. 2. Some examples of triangles



EXAMPLE

Calculate the surface area of the triangles no. 1, no. 1a and no. 2

	Given		Answer
Triangles no. 1 and no. 1a:	base = 3 cm height = 2 cm	Formula:	A = 0.5 x base x height = 0.5 x 3 cm x 2 cm = 3 cm^2
Triangle no. 2:	base = 3 cm height = 2 cm		A = 0.5 x 3 cm x 2 cm = 3 cm^2

It can be seen that triangles no. 1, no. 1a and no. 2 have the same surface; the shapes of the triangles are different, but the base and the height are in all three cases the same, so the surface is the same.

The surface of these triangles is expressed in square centimetres (written as cm^2). Surface areas can

also be expressed in square decimetres (dm^2), square metres (m^2), etc...

QUESTION

Calculate the surface areas of the triangles nos. 3, 4, 5 and 6.

	Given		Answer
Triangle no. 3:	base = 3 cm height = 2 cm	Formula:	A = 0.5 x base x height = 0.5 x 3 cm x 2 cm = 3 cm^2
Triangle no. 4:	base = 4 cm height = 1 cm		A = 0.5 x 4 cm x 1 cm = 2 cm^2
Triangle no. 5:	base = 2 cm height = 3 cm		A = 0.5 x 2 cm x 3 cm = 3 cm^2
Triangle no. 6:	base = 4 cm height = 3 cm		A = 0.5 x 4 cm x 3 cm = 6 cm^2

1.1.2 Squares and Rectangles

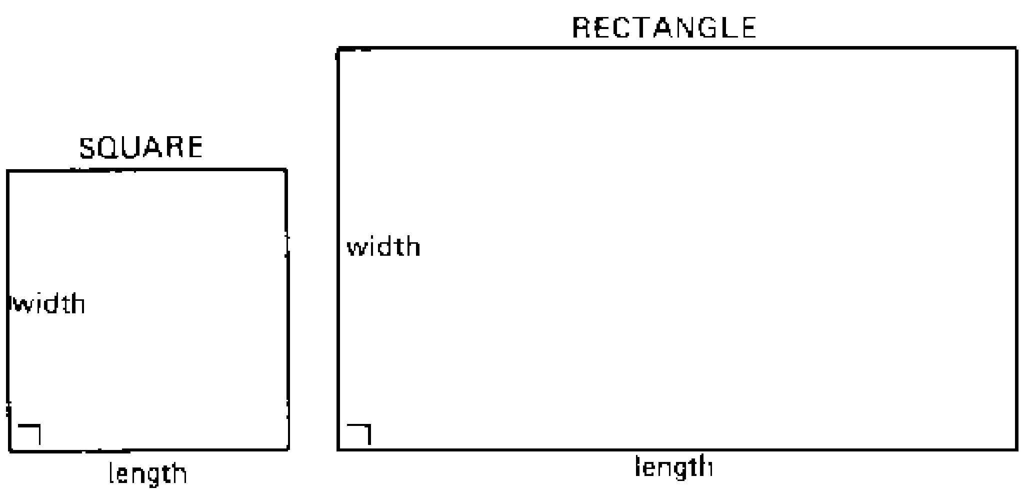
The surface area or surface (A) of a square or a rectangle is calculated by the formula:

A (square or rectangle) = length x width = l x w ..... (2)

In a square the lengths of all four sides are equal and all four angles are right angles.

In a rectangle, the lengths of the opposite sides are equal and all four angles are right angles.

Fig. 3. A square and a rectangle



Note that in a square the length and width are equal and that in a rectangle the length and width are not equal (see Fig. 3).

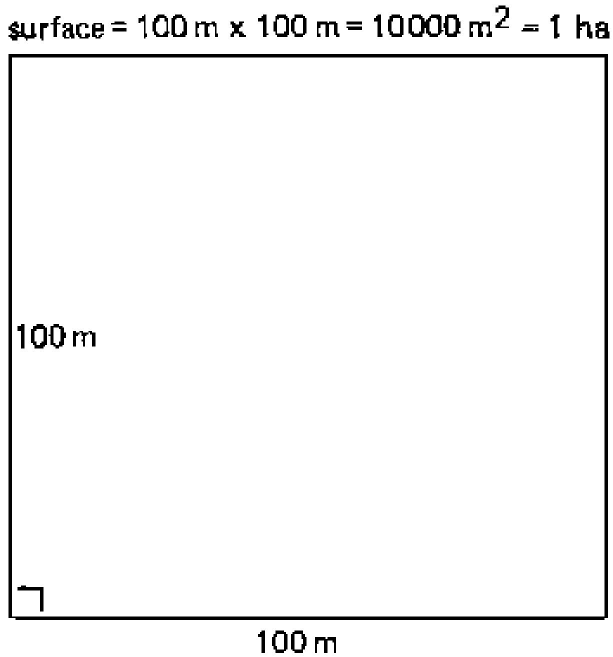
QUESTION

Calculate the surface areas of the rectangle and of the square (see Fig. 3).

	Given		Answer
Square:	length = 2 cm width = 2 cm	Formula:	A = length x width = 2 cm x 2 cm = 4 cm^2
Rectangle:	length = 5 cm width = 3 cm	Formula:	A = length x width = 5 cm x 3 cm = 15 cm^2

Related to irrigation, you will often come across the expression hectare (ha), which is a surface area unit. By definition, 1 hectare equals 10 000 m^2. For example, a field with a length of 100 m and a width of 100 m^2 (see Fig. 4) has a surface area of 100 m x 100 m = 10 000 m^2 = 1 ha.

Fig. 4. One hectare equals 10 000 m^2



1.1.3 Rhombuses and Parallelograms

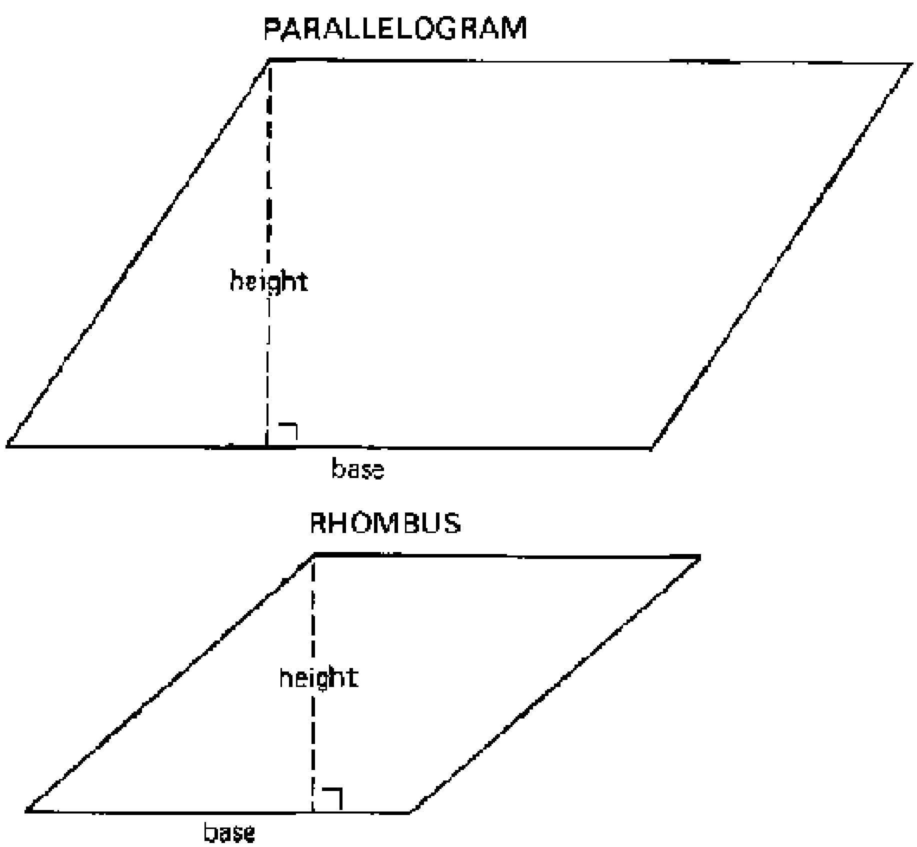
The surface area or surface (A) of a rhombus or a parallelogram is calculated by the formula:

A (rhombus or parallelogram) = base x height = b x h ..... (3)

In a rhombus the lengths of all four sides are equal; none of the angles are right angles; opposite sides run parallel.

In a parallelogram the lengths of the opposite sides are equal; none of the angles are right angles; opposite sides run parallel (see Fig. 5).

Fig. 5. A rhombus and a parallelogram



QUESTION

Calculate the surface areas of the rhombus and the parallelogram (see Fig. 5).

	Given		Answer
Rhombus:	base = 3 cm height = 2 cm	Formula:	A = base x height = 3 cm x 2 cm = 6 cm^2
Parallelogram:	base = 3.5 cm height = 3 cm	Formula:	A = base x height = 3.5 cm x 3 cm = 10.5 cm^2

1.1.4 Trapeziums

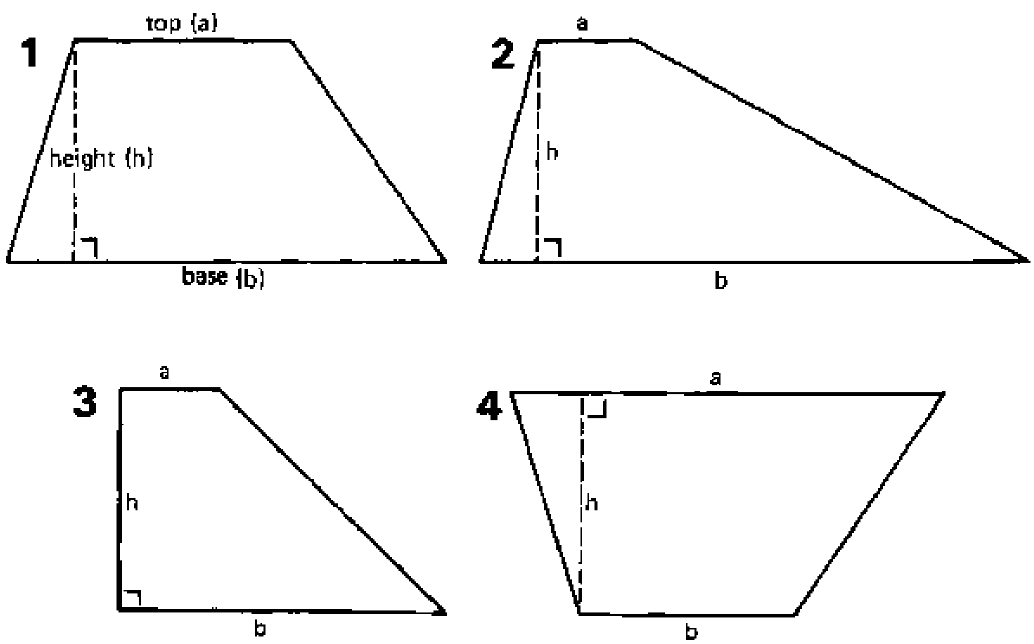
The surface area or surface (A) of a trapezium is calculated by the formula:

A (trapezium) = 0.5 (base + top) x height = 0.5 (b + a) x h ..... (4)

The top (a) is the side opposite and parallel to the base (b). In a trapezium only the base and the top run parallel.

Some examples are shown in Fig. 6:

Fig. 6. Some examples of trapeziums



EXAMPLE

Calculate the surface area of trapezium no. 1.

	Given		Answer
Trapezium no. 1:	base = 4 cm top = 2 cm height = 2 cm	Formula:	A = 0.5 x (base x top) x height = 0.5 x (4 cm + 2 cm) x 2 cm = 0.5 x 6 cm x 2 cm = 6 cm^2

QUESTION

Calculate the surface areas trapeziums nos. 2, 3 and 4.

	Given		Answer
Trapezium no. 2:	base = 5 cm top = 1 cm height = 2 cm	Formula:	A = 0.5 x (base + top) x height = 0.5 x (5 cm + 1 cm) x 2 cm = 0.5 x 6 cm x 2 cm = 6 cm^2
Trapezium no. 3:	base = 3 cm top = 1 cm		A = 0.5 x (3 cm + 1 cm) x 2 cm = 0.5 x 4 cm x 2 cm = 4 cm^2

height = 1 cm

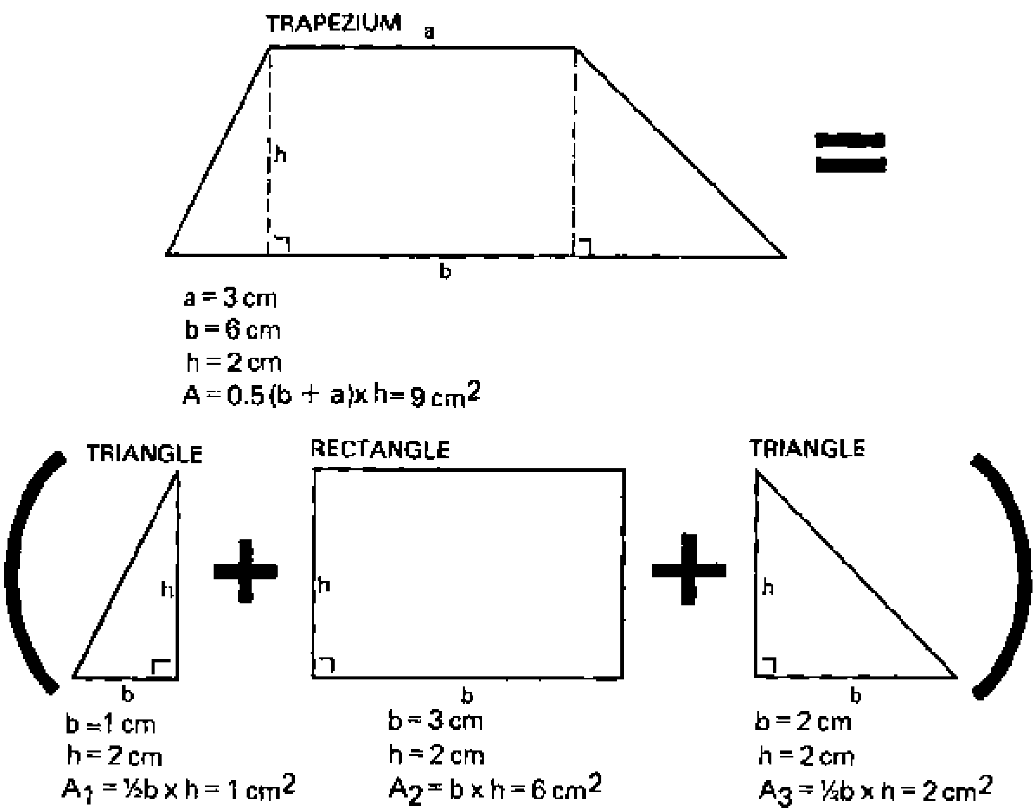
Trapezium no. 4: base = 2 cm; top = 4 cm; height = 2 cm

A = 0.5 x (2 cm + 4 cm) x 2 cm
= 0.5 x 6 cm x 2 cm = 6 cm^2

Note that the surface areas of the trapeziums 1 and 4 are equal. Number 4 is the same as number 1 but upside down.

Another method to calculate the surface area of a trapezium is to divide the trapezium into a rectangle and two triangles, to measure their sides and to determine separately the surface areas of the rectangle and the two triangles (see Fig. 7).

Fig. 7. Splitting a trapezium into one rectangle and two triangles. Note that $A = A_1 + A_2 + A_3 = 1 + 6 + 2 = 9$ cm^2



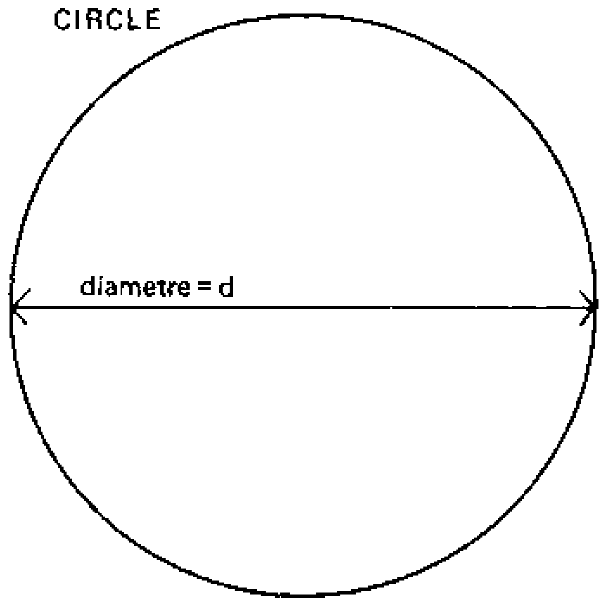
1.1.5 Circles

The surface area or surface (A) of a circle is calculated by the formula:

A (circle) = 1/4 (π x d x d) = 1/4 (π x d^2) = 1/4 (3.14 x d^2) ..... (5)

whereby d is the diameter of the circle and π (a Greek letter, pronounced Pi) a constant (π = 3.14). A diameter (d) is a straight line which divides the circle in two equal parts.

Fig. 8. A circle



EXAMPLE

Given		Answer
Circle: d = 4.5 cm	Formula:	A = 1/4 (π x d²)
		= 1/4 (3.14 x d x d)
		= 1/4 (3.14 x 4.5 cm x 4.5 cm)
		= 15.9 cm^2

QUESTION

Calculate the surface area of a circle with a diameter of 3 m.

Given		Answer
Circle: d = 3 m	Formula:	A = 1/4 (π x d²) = 1/4 (3.14 x d x d)
		= 1/4 (3.14 x 3 m x 3 m) = 7.07 m^2

1.1.6 Metric Conversions

i. Units of length

The basic unit of length in the metric system is the metre (m). One metre can be divided into 10 decimetres (dm), 100 centimetres (cm) or 1000 millimetres (mm); 100 m equals to 1 hectometre (hm); while 1000 m is 1 kilometre (km).

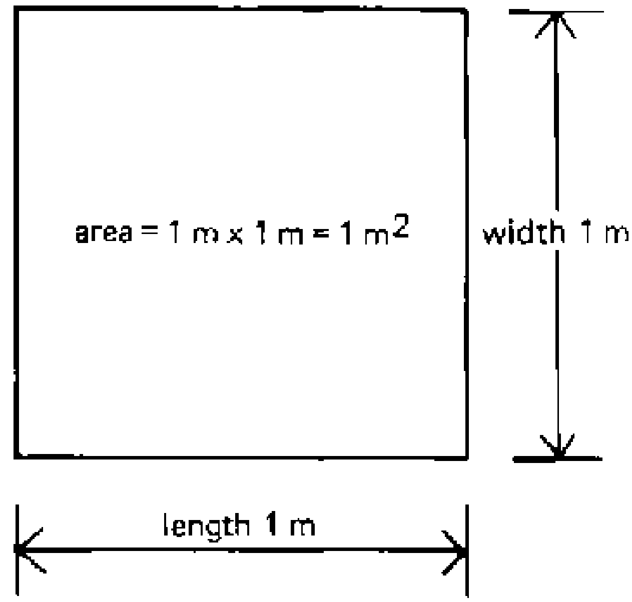
1 m = 10 dm = 100 cm = 1000 mm
0.1 m = 1 dm = 10 cm = 100 mm
0.01 m = 0.1 dm = 1 cm = 10 mm
0.001 m = 0.01 dm = 0.1 cm = 1 mm

1 km = 10 hm = 1000 m
0.1 km = 1 hm = 100 m
0.01 km = 0.1 hm = 10 m
0.001 km = 0.01 hm = 1 m

ii. Units of surface

The basic unit of area in the metric system is the square metre (m), which is obtained by multiplying a length of 1 metre by a width of 1 metre (see Fig. 9).

Fig. 9. A square metre



$1\ m^2 = 100\ dm^2 = 10\ 000\ cm^2 = 1\ 000\ 000\ mm^2$
$0.01\ m^2 = 1\ dm^2 = 100\ cm^2 = 10\ 000\ mm^2$
$0.0001\ m^2 = 0.01\ dm^2 = 1\ cm^2 = 100\ mm^2$
$0.000001\ m^2 = 0.0001\ dm^2 = 0.01\ cm^2 = 1\ mm^2$

$1\ km^2 = 100\ ha^2 = 1\ 000\ 000\ m^2$
$0.01\ km^2 = 1\ ha^2 = 10\ 000\ m^2$
$0.000001\ km^2 = 0.0001\ ha^2 = 1\ m^2$

NOTE:

1 ha = 100 m x 100 m = 10 000 m^2

1.2 Surface areas of canal cross-sections and farms

1.2.1 Determination of the surface areas of canal cross-sections
1.2.2 Determination of the surface area of a farm

This Section explains how to apply the surface area formulas to two common practical problems that will often be met in the field.

1.2.1 Determination of the surface areas of canal cross-sections

The most common shape of a canal cross-section is a trapezium or, more truly, an "up-side-down" trapezium (see Fig. 10).

Fig. 10. Canal cross-section

The area (A B C D), hatched on the above drawing, is called the canal cross-section and has a trapezium shape (compare with trapezium no. 4). Thus, the formula to calculate its surface is similar to the formula used to calculate the surface area of a trapezium (formula 4):

Surface area of the canal cross-section = 0.5 (base + top line) x canal depth = 0.5 (b + a) x h ..... (6)

whereby:

base (b) = bottom width of the canal

top line (a) = top width of the canal

canal depth (h) = height of the canal (from the bottom of the canal to the top of the

embankment)

Suppose that the canal contains water, as shown in Fig. 11.

[Fig. 11. Wetted cross-section of a canal]

The area (A B C D), hatched on the above drawing, is called the wetted canal cross-section or wetted cross-section. It also has a trapezium shape and the formula to calculate its surface area is:

Surface area of the wetted canal cross-section = 0.5 (base + top line) x water depth = 0.5 (b + a_1) x h_1 ..... (7)

whereby:

base (b) = bottom width of the canal

top line (a_1) = top width of the water level

water depth (h_1) = the height or depth of the water in the canal (from the bottom of the canal to the water level).

EXAMPLE

Calculate the surface area of the cross-section and the wetted cross-section, of the canal shown in Fig. 12 below.

[Fig. 12. Dimensions of the cross-section]

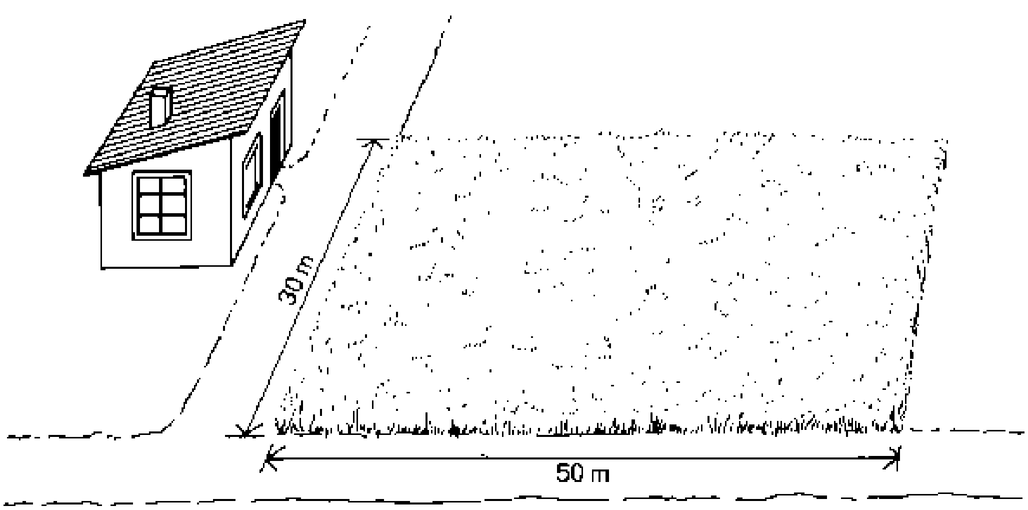
Given		Answer
Canal cross-section:		
base (b) = 1.25 m top line (a) = 3.75 m canal depth (h) = 1.25 m	Formula:	A = 0.5 x (b + a) x h = 0.5 x (1.25 m + 3.75 m) x 1.25 m = 3.125 m^2
Canal wetted cross-section:		
base (b) = 1.25 m top line (a_1) = 3.25 m water depth (h_1) = 1.00 m	Formula:	A = 0.5 x (b + a_1) x h = 0.5 x (1.25 m + 3.25 m) x 1.00 m = 2.25 m^2

1.2.2 Determination of the surface area of a farm

It may be necessary to determine the surface area of a farmer's field. For example, when calculating how much irrigation water should be given to a certain field, the size of the field must be known.

When the shape of the field is regular and has, for example, a rectangular shape, it should not be too difficult to calculate the surface area once the length of the field (that is the base of its regular shape) and the width of the field have been measured (see Fig. 13).

Fig. 13. Field of regular shape



EXAMPLE

Given		Answer
Length of the field = 50 m	Formula:	A = length x width (formula 2)
Width of the field = 30 m		= 50 m x 30 m = 1500 m^2

QUESTION

What is the area of the same field, expressed in hectares?

ANSWER

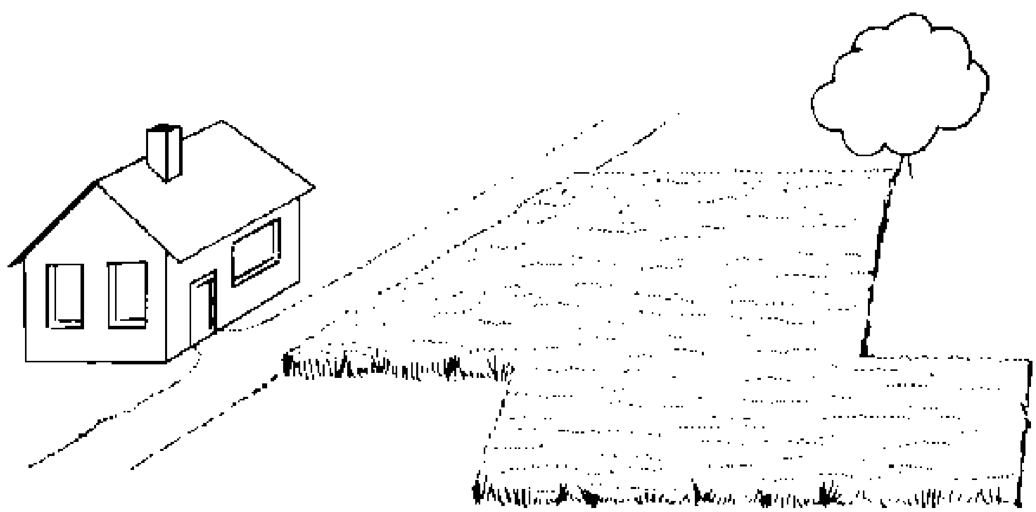
Section 1.1.2 explained that a hectare is equal to 10 000 m. Thus, the formula to calculate a surface area in hectares is:

$$\text{Surface area in hectares (ha)} = \frac{\text{surface area in square metres } (m^2)}{10\,000} \quad \text{..... (8)}$$

In this case: area of the field in $ha = \frac{1500\, m^2}{10\,000} = 0.15\, ha$

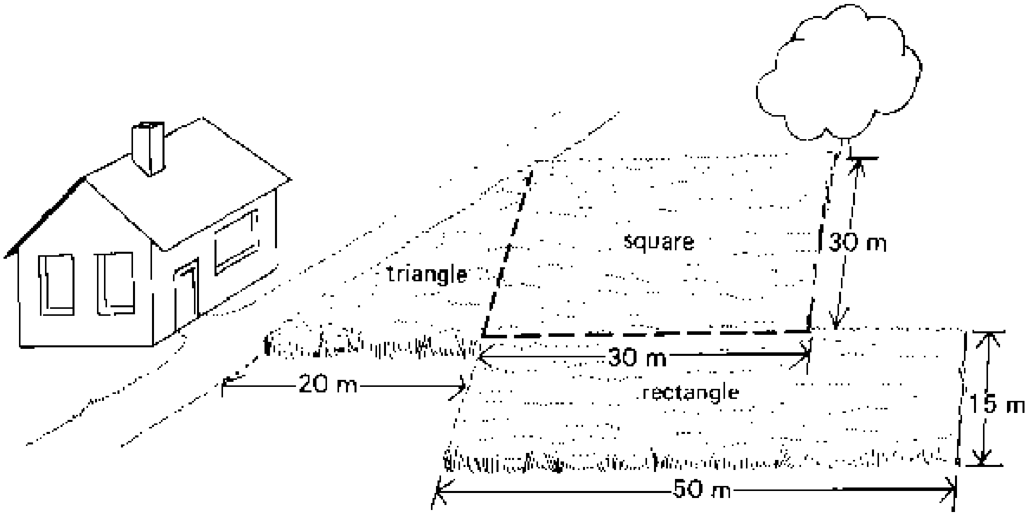
More often, however, the field shape is not regular, as shown in Fig. 14a.

Fig. 14a. Field of irregular shape



In this case, the field should be divided in several regular areas (square, rectangle, triangle, etc.), as has been done in Fig. 14b.

Fig. 14b. Division of irregular field into regular areas



Surface area of the square: A_s = length x width = 30 m x 30 m = 900 m^2

Surface area of the rectangle: A_r = length x width = 50 m x 15 m = 750 m^2

Surface area of the triangle: A_t = 0.5 x base x height = 0.5 x 20 m x 30 m = 300 m^2

Total surface area of the field: A = A_s + A_r + A_t = 900 m^2 + 750 m^2 + 300 m^2 = 1950 m^2

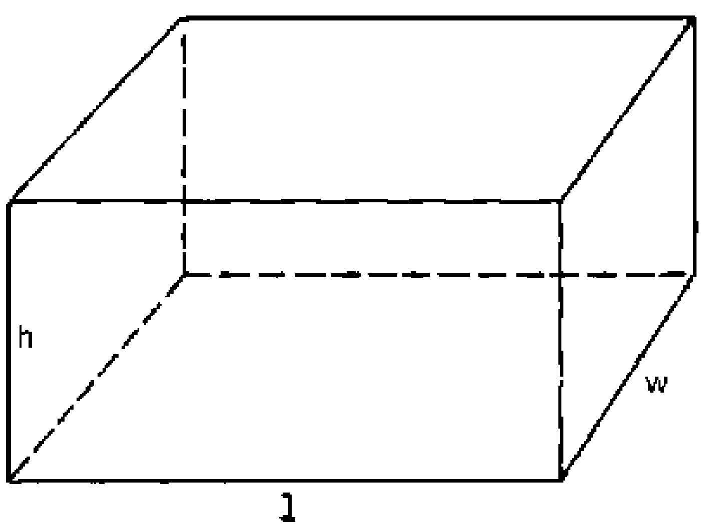
1.3 Introduction to volume

[1.3.1 Units of volume]
[1.3.2 Volume of water on a field]

A volume (V) is the content of a body or object. Take for example a block (Fig 15). A block has a certain length (l), width (w) and height (h). With these three data, the volume of the block can be calculated using the formula:

V (block) = length x width x height = l x w x h ..... (9)

Fig. 15. A block



EXAMPLE

Calculate the volume of the above block.

Given		Answer
length = 4 cm	Formula:	V = length x width x height
width = 3 cm		= 4 cm x 3 cm x 2 cm

height = 2 cm = 24 cm^3

The volume of this block is expressed in cubic centimetres (written as cm). Volumes can also be expressed in cubic decimetres (dm^3), cubic metres (m^3), etc.

QUESTION

Calculate the volume in m^3 of a block with a length of 4 m, a width of 50 cm and a height of 200 mm.

Given		Answer
All data must be converted in metres (m)		
length = 4 m	Formula:	V = length x width x height
width = 50 cm = 0.50 m		= 4 m x 0.50 m x 0.20 m
height = 200 mm = 0.20 m		= 0.40 m^3

QUESTION

Calculate the volume of the same block, this time in cubic centimetres (cm^3)

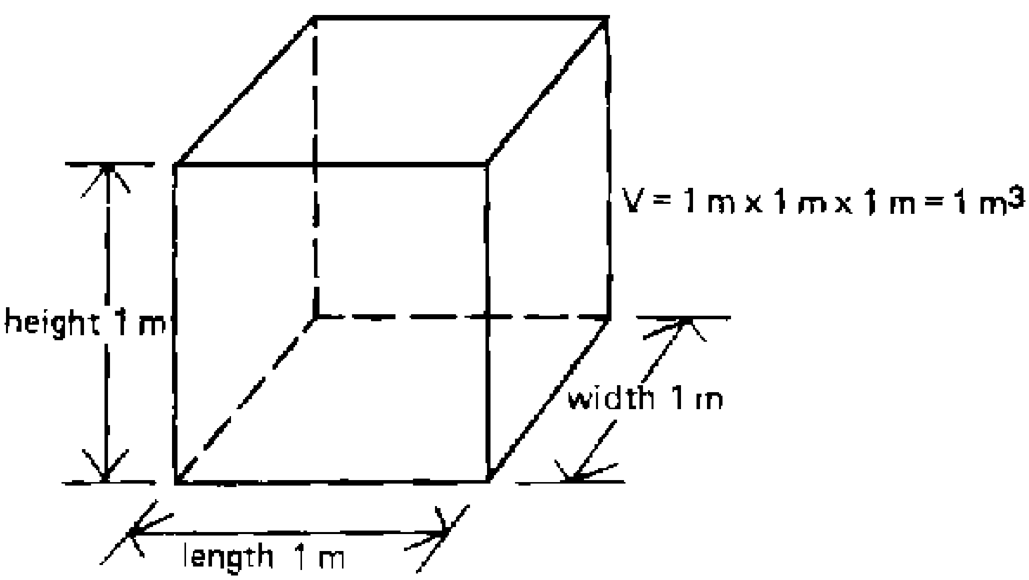
Given		Answer
All data must be converted in centimetres (cm)		
length = 4 m = 400 cm	Formula:	V = length x width x height
width = 50 cm		= 400 cm x 50 cm x 20 cm
height = 200 mm = 20 cm		= 400 000 cm^3

Of course, the result is the same: 0.4 m^3 = 400 000 cm^3

1.3.1 Units of volume

The basic unit of volume in the metric system is the cubic metre (m^3) which is obtained by multiplying a length of 1 metre, by a width of 1 metre and a height of 1 metre (see Fig. 16).

Fig. 16. One cubic metre



1 m^3 = 1.000 dm^3 = 1 000 000 cm^3 = 1 000 000 000 mm^3
0.001 m^3 = 1 dm^3 = 1 000 cm^3 = 1 000 000 mm^3
0.000001 m^3 = 0.001 dm^3 = 1 cm^3 = 1 000 mm^3
0.000000001 m^3 = 0.000001 dm^3 = 0.001 cm^3 = 1 mm^3

NOTE

1 dm^3 = 1 litre

and

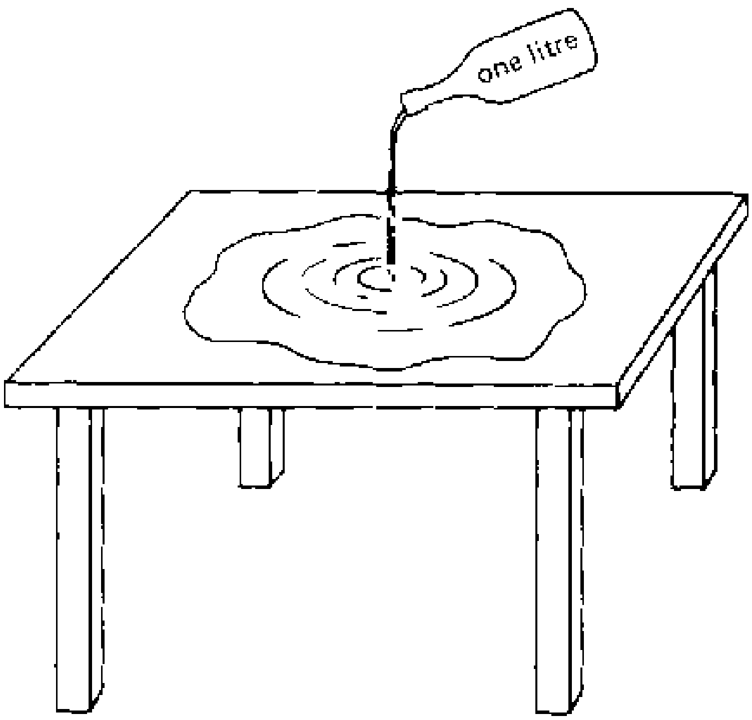
$$1\ m^3 = 1000\ litres$$

1.3.2 Volume of water on a field

Suppose a one-litre bottle is filled with water. The volume of the water is thus 1 litre or 1 dm^3. When the bottle of water is emptied on a table, the water will spread out over the table and form a thin water layer. The amount of water on the table is the same as the amount of water that was in the bottle; being 1 litre.

The volume of water remains the same; only the shape of the "water body" changes (see Fig. 17).

Fig. 17. One litre of water spread over a table



A similar process happens if you spread irrigation water from a storage reservoir over a farmer's field.

QUESTION

Suppose there is a reservoir, filled with water, with a length of 5 m, a width of 10 m and a depth of 2 m. All the water from the reservoir is spread over a field of 1 hectare. Calculate the water depth (which is the thickness of the water layer) on the field, see Fig. 18.

Fig. 18. A volume of 100 m^3 of water spread over an area of one hectare

The formula to use is:

$$\text{Water depth } (d) = \frac{\text{Volume of water } (V)}{\text{Surface of the field } (A)} \quad \text{.....} \ (10)$$

As the first step, the volume of water must be calculated. It is the volume of the filled reservoir, calculated with formula (9):

Volume (V) = length x width x height = 5 m x 10 m x 2 m = 100 m^3

As the second step, the thickness of the water layer is calculated using formula (10):

Given		Answer
Surface of the field = 10 000 m^2 Volume of water = 100 m^3	Formula:	$d = \frac{\text{Volume of water } (m^3)}{\text{Surface of the field } (m^2)}$

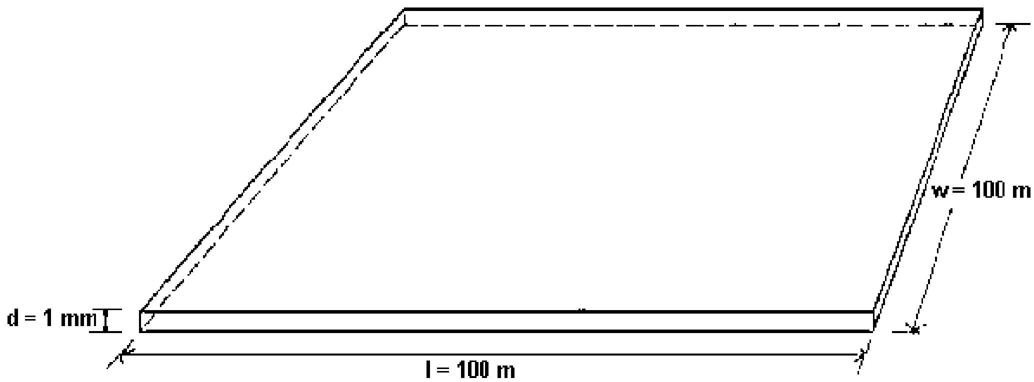
$$d = \frac{100\ (m^3)}{10\ 000\ (m^2)}$$

$d = 0.01$ m
$d = 10$ mm

QUESTION

A water layer 1 mm thick is spread over a field of 1 ha. Calculate the volume of the water (in m^3), with the help of Fig. 19.

Fig. 19. One millimetre water depth on a field of one hectare



The formula to use is:

Volume of water (V) = Surface of the field (A) x Water depth (d) ..... (11)

Given		Answer
Surface of the field = 10 000 m^2	Formula: Volume (m^3)	= surface of the field (m^2) x water depth (m)
Water depth = 1 mm =1/1 000 = 0.001 m		V = 10 000 m^2 x 0.001 m
		V = 10 m^3 or 10 000 litres

1.4 Introduction to flow-rate

1.4.1 Definition
1.4.2 Calculation and Units

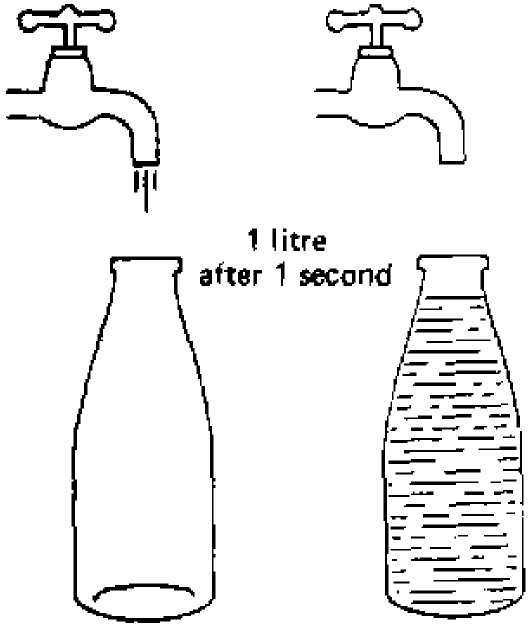
1.4.1 Definition

The flow-rate of a river, or of a canal, is the volume of water discharged through this river, or this canal, during a given period of time. Related to irrigation, the volume of water is usually expressed in litres (l) or cubic metres (m^3) and the time in seconds (s) or hours (h). The flow-rate is also called discharge-rate.

1.4.2 Calculation and Units

The water running out of a tap fills a one litre bottle in one second. Thus the flow rate (Q) is one litre per second (1 l/s) (see Fig. 20).

Fig. 20. A flow-rate of one litre per second



QUESTION

The water supplied by a pump fills a drum of 200 litres in 20 seconds. What is the flow rate of this pump?

The formula used is:

$$Q = \text{Flow-rate}\ (\text{l/s}) = \frac{\text{Volume of water (litres)}}{\text{Time (seconds)}} \quad ..... (12a)$$

Given	Answer
Volume of water: 200 l Time: 20 s	Formula: $Q = \frac{\text{Volume of water}}{\text{Time}} = \frac{200\ \text{l}}{20\ \text{s}} = 10\ \text{l/s}$

The unit "litre per second" is commonly used for small flows, e.g. a tap or a small ditch. For larger flows, e.g. a river or a main canal, the unit "cubic metre per second" (m^3/s) is more conveniently used.

QUESTION

A river discharges 100 m^3 of water to the sea every 2 seconds. What is the flow-rate of this river expressed in m^3/s?

The formula used is:

$$Q = \text{Flow-rate}\ (m^3/s) = \frac{\text{Volume of water}\ (m^3)}{\text{Time (seconds)}} \quad ..... (12b)$$

Given	Answer
Volume of water: 100 m^3 Time: 2 s	Formula: $Q = \frac{\text{Volume of water}}{\text{Time}} = \frac{100\ m^3}{2\ s} = 50\ m^3/s$

The discharge rate of a pump is often expressed in m^3 per hour (m^3/h) or in litres per minute (l/min).

$$Q = \text{Flow-rate}\ (\text{l/min}) = \frac{\text{Volume of water (litres)}}{\text{Time (minutes)}} \quad ..... (12c)$$

$$Q = \text{Flow-rate}\left(m^3/h\right) = \frac{\text{Volume of water}\left(m^3\right)}{\text{Time (hours)}} \quad ..... \text{(12d)}$$

NOTE: Formula 12a, 12b, 12c and 12d are the same; only the units change

1.5 Introduction to percentage and per mil

1.5.1 Percentage
1.5.2 Per mil

In relation to agriculture, the words percentage and per mil will be met regularly. For instance "60 percent of the total area is irrigated during the dry season". In this Section the meaning of the words "percentage" and "per mil" will be discussed.

1.5.1 Percentage

The word "percentage" means literally "per hundred"; in other words one percent is the one hundredth part of the total. You can either write percent, or %, or 1/100, or 0.01.

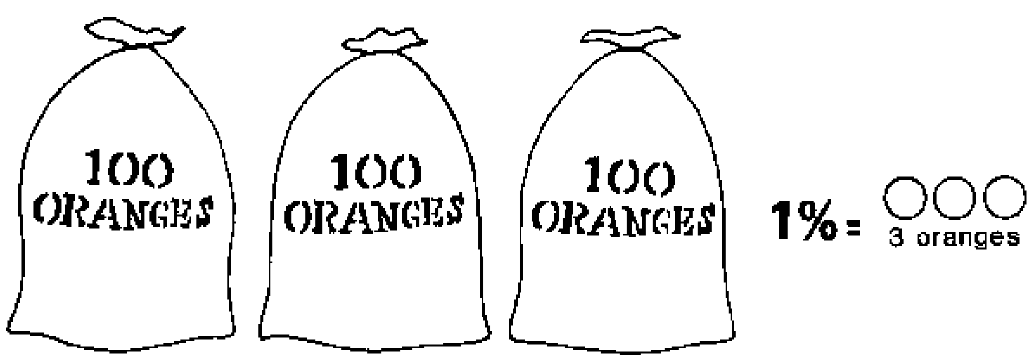
Some examples are:

5 percent = 5% =5/100 = 0.05
20 percent = 20% = 20/100= 0.20
25 percent = 25% = 25/100 = 0.25
50 percent = 50% = 50/100 =0.50
100 percent = 100% = 100/100 = 1
150 percent = 150% = 150/100 = 1.5

QUESTION

How many oranges are 1% of a total of 300 oranges? (see Fig. 21)

Fig. 21. Three oranges are 1% of 300 oranges



ANSWER

1% of 300 oranges = 1/100 x 300 = 3 oranges

QUESTIONS	ANSWERS
6% of 100 cows	6/100 x 100 = 6 cows
15% of 28 hectares	15/100 x 28 = 4.2 ha
80% of 90 irrigation projects	80/100 x 90 = 72 projects
150% of a monthly salary of $100	150/100 x 100 = 1.5 x 100 = $150
0.5% of 194.5 litres	0.5/100 x 194.5 = 0.005 x 194.5 = 0.9725 litres

1.5.2 Per mil

The word "per mil" means literally "per thousand"; in other words one per mil is one thousandth part of the total.

You can either write: per mil, or ‰, or 1/1000, or 0.001.

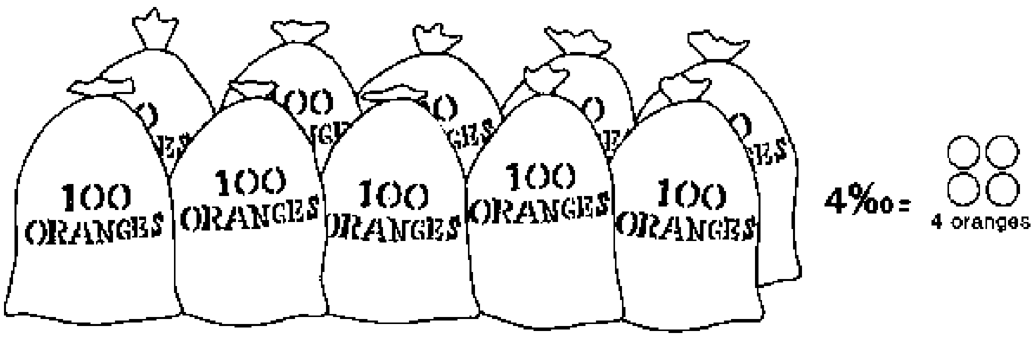
Some examples are:

> 5 per mil = 5‰ =5/1000= 0.005
> 50 per mil = 50‰ = 50/1000 = 0.050
> 95 per mil = 95‰ = 95/1000 = 0.095

QUESTION

How many oranges are 4‰ of 1000 oranges? (see Fig. 22)

Fig. 22. Four oranges are 4‰ of 1000 oranges



ANSWER

4‰ of 1000 oranges = 4/1000 x 1000 = 4 oranges

NOTE

10‰ = 1%

because 10‰ = 10/1000 = 1/10 = 1%

QUESTIONS	ANSWERS
3‰ of 3 000 oranges	3/1000 x 3 000 = 9 oranges
35‰ of 10 000 ha	35/1000 x 10 000 = 350 ha
0.5‰ of 750 km^2	0.5/1000 x 750 =0.375 km^2

1.6 Introduction to graphs

> 1.6.1 Example 1
> 1.6.2 Example 2

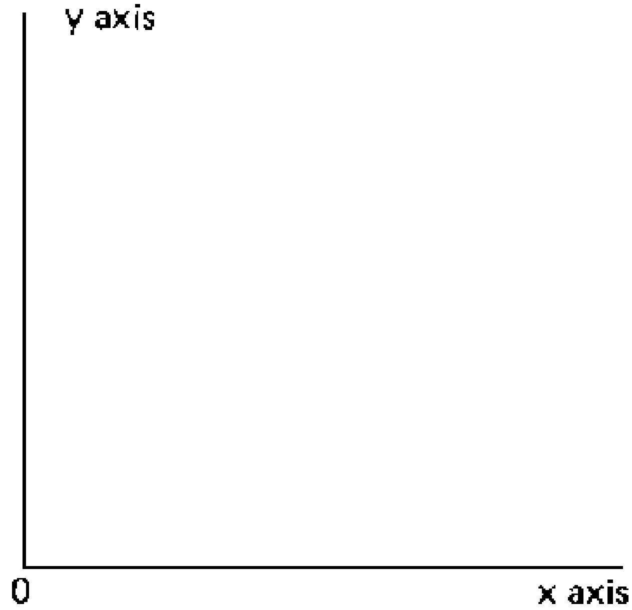
A graph is a drawing in which the relationship between two (or more) items of information (e.g. time and plant growth) is shown in a symbolic way.

To this end, two lines are drawn at a right angle. The horizontal one is called the x axis and the vertical one is called the y axis.

Where the x axis and the y axis intersect is the "0" (zero) point (see Fig. 23).

The plotting of the information on the graph is discussed in the following examples.

Fig. 23. A graph



1.6.1 Example 1

Suppose it is necessary to make a graph of the growth rate of a maize plant. Each week the height of the plant is measured. One week after planting the seed, the plant measures 2 cm in height, two weeks after planting it measures 5 cm and 3 weeks after planting the height is 10 cm, as illustrated in Fig. 24a.

Fig. 24a. Measuring the growth rate of a maize plant

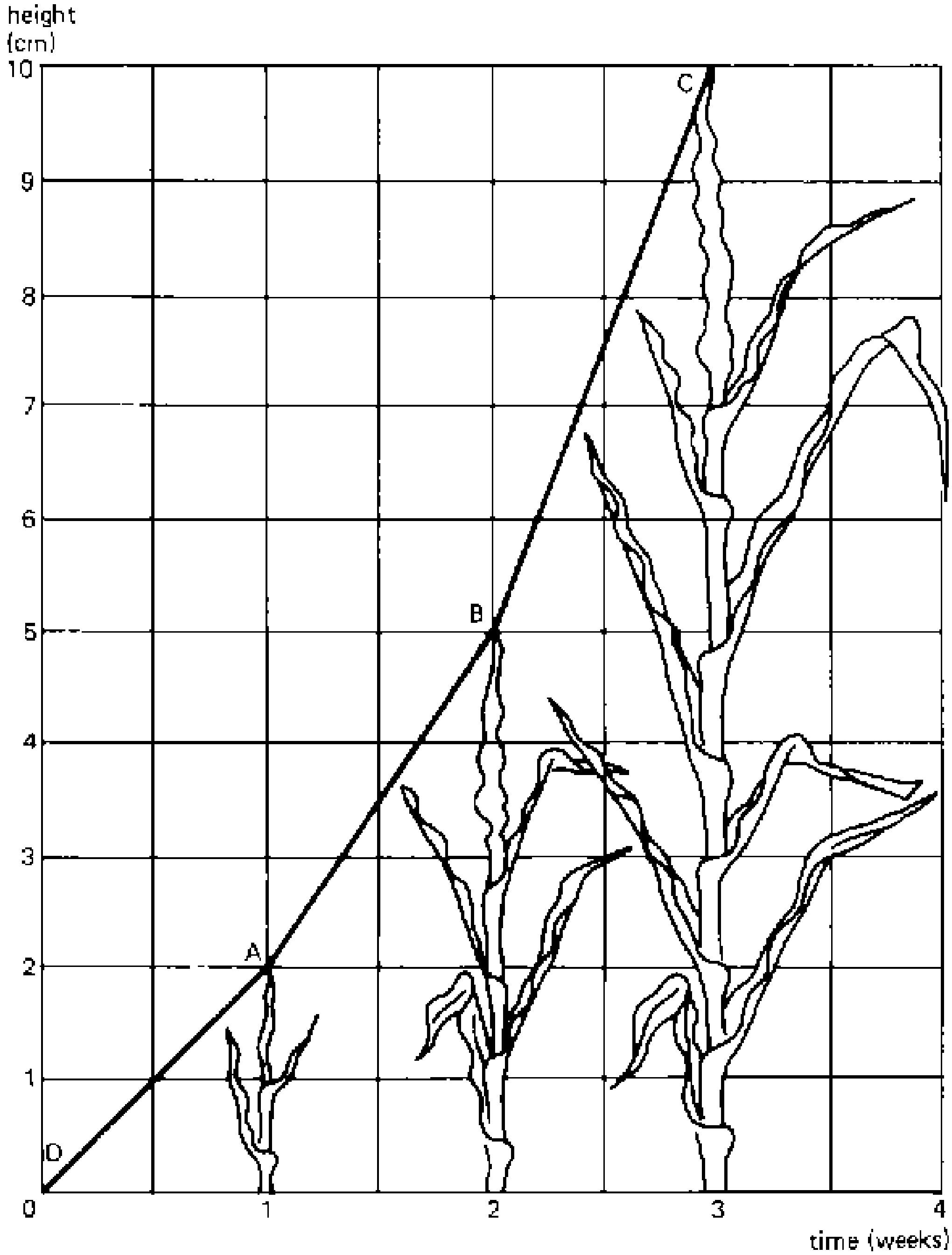
These results can be plotted on a graph. The time (in weeks) will be indicated on the x axis; 2 cm on the axis represents 1 week. The plant height (in centimetres) will be indicated on the y axis; 1 cm on the axis represents 1 cm of plant height.

After 1 week the height is 2 cm; this is indicated on the graph with A; after 2 weeks the height is 5 cm, see B, and after 3 weeks the height is 10 cm, see C, as shown in Fig. 24b.

At planting (Time = 0) the height was zero, see D.

Now connect the crosses (see Fig. 24c) with a straight line. The line indicates the growth rate of the plant; this is the height increase over time.

Fig. 24b. Growth rate of a maize plant



It can be seen from the graph that the plant is growing faster and faster (during the first week 2 cm and during the third week 5 cm); the line from B to C is steeper than the line from D to A.

From the graph can be read what the height of the plant was after, say 2 1/2 weeks; see the dotted line (Fig. 24c). Locate on the horizontal axis 2 1/2 weeks and follow the dotted line upwards until the dotted line crosses the graph. From this crossing follow the dotted line to the left until the vertical axis is reached. Now take the reading: 7.5 cm, which means that the plant had a height of 7.5 cm after 2 1/2 weeks. This height has not been measured in reality, but with the graph the height can be determined anyway.

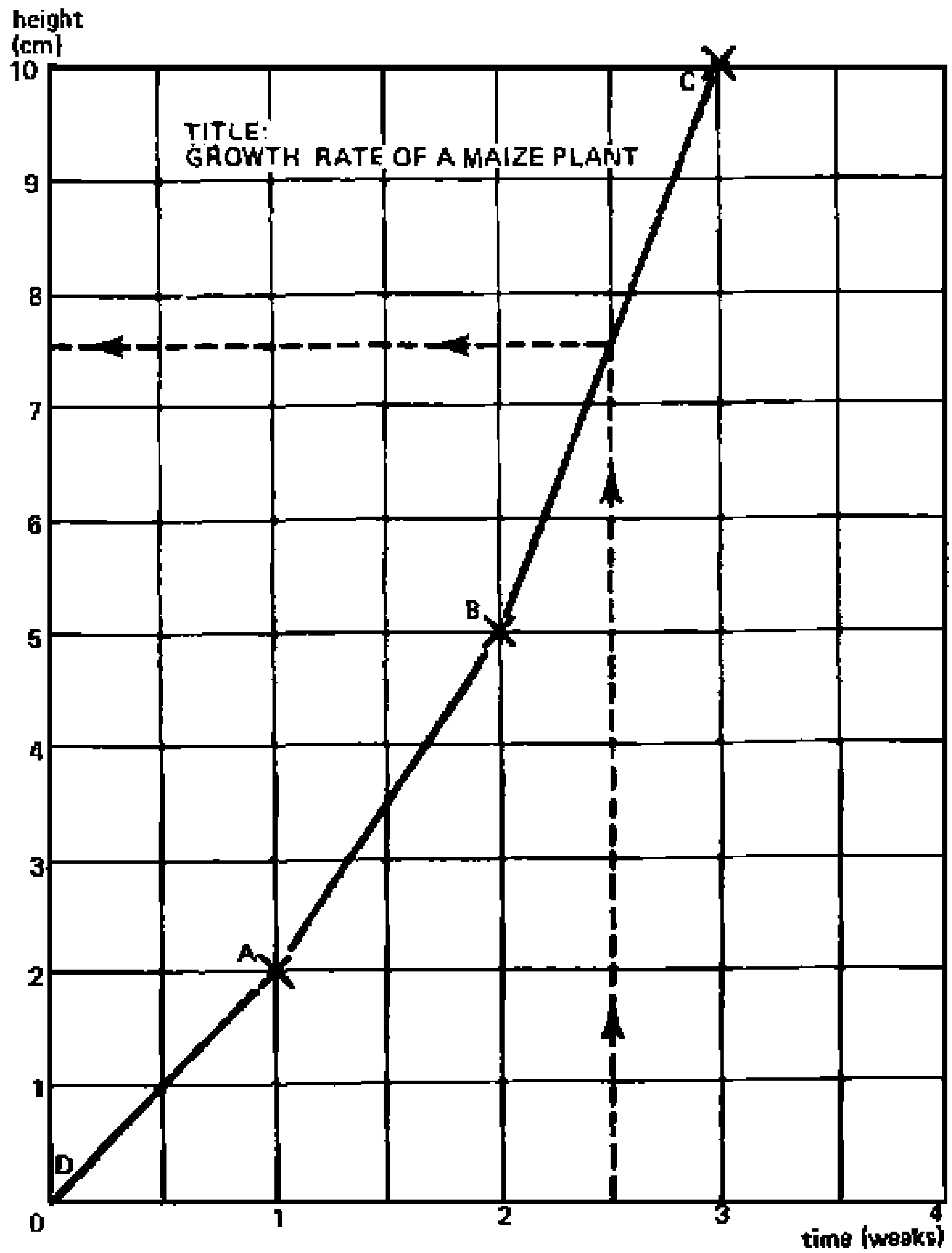
<u>QUESTION</u>

What was the height of the plant after 1 1/2 weeks?

<u>ANSWER</u>

The height of the plant after 1 1/2 weeks was 3.5 cm (see Fig. 24c).

Fig. 24c. Graph of the growth rate of a maize plant



1.6.2 Example 2

Another example to illustrate how a graph should be made is the variation of the temperature over one full day (24 hours). Suppose the outside temperature (always in the shade) is measured, with a thermometer, every two hours, starting at midnight and ending the following midnight.

Suppose the following results are found:

Time (hr)	Temperature (°C)
0	16
2	13
4	6
6	8
8	13
10	19
12	24
14	28

16	2
18	27
20	22
22	19
24	16

On the x axis indicate the time in hours, whereby 1 cm on the graph is 2 hours. On the y axis indicate the temperature in degrees Celsius (°C), whereby 1 cm on the graph is 5°C.

Now indicate (with crosses) the values from the table (above) on the graph paper and connect the crosses with straight dotted lines (see Fig. 25a).

Fig. 25a. Graph showing temperature over 24 hours; mistake 16 hour reading

At this stage, if you look attentively at the graph, you will note that there is a very abrupt change in its shape around the sixteenth hour. The outside temperature seems to have fallen from 28°C to 2°C in two hours time! That does not make sense, and the reading of the thermometer at the sixteenth hour must have been wrong. This cross cannot be taken in consideration for the graph and should be rejected. The only dotted line we can accept is the straight one in between the reading at the fourteenth hour and the reading at the eighteenth hour (see Fig. 25b).

Fig. 25b. Graph showing temperature over 24 hours; estimated correction of mistake

In reality the temperature will change more gradually than indicated by the dotted line; that is why a smooth curve is made (continuous line). The smooth curve represents the most realistic approximation of the temperature over 24 hours (see Fig. 25c).

Fig. 25c. Graph showing temperature over 24 hours; smooth curve

From the graph it can be seen that the minimum or lowest temperature was reached around 4 o'clock in the morning and was about 6°C. The highest temperature was reached at 4 o'clock in the afternoon and was approximately 29°C.

QUESTION

What was the temperature at 7, 15 and 23 hours? (Always use the smooth curve to take the readings).

ANSWER (see Fig. 25c)

Temperature at 7 hours: 10°C
Temperature at 15 hours: 29°C
Temperature at 23 hours: 17°C

1.7 Test your knowledge

1.7.1 Questions
1.7.2 Answers

1.7.1 Questions

1) Calculate the surface areas of the following triangles:

a. height = 6 cm, base = 12 cm = = = A = ...cm^2
b. height = 22 cm, base = 48 cm = = = A = ...cm^2
c. height = 16 cm, base = 24 cm = = = A = ...cm^2
d. height = 0.8 m, base = 0.3 m = = = A = ...m^2

2) Calculate the surface areas of the following trapeziums:

a. height = 12 cm, base = 52 cm, top = 16 cm = = = A = ...cm^2
b. height = 20 cm, base = 108 dm, top = 16 cm = = = A = ...cm^2
c. height = 0.3 m, base = 1.8 m, top = 1.5 m = = = A = ...m^2

3) Calculate the cross-section of the canal when given:

height = 1 m
top width = 2.6 m
bottom width = 1.2 m

4) Calculate the wetted cross-section when in addition to 3) is given that the water height is 0.8 m and the top width of the water surface is 2.32 m.

5) A rectangular field has a length of 120 m and a width of 85 m. What is the area of the field in hectares?

6)

a. 25% of 1820 metres = ...metres
b. 13% of 971 cm = ...cm
c. 83% of 8000 apples = ...apples
d. 7‰ of 18 060 metres = ...metres
e. 13% of 26 hectares = ...hectares
f. 1.5‰ of 28 000 metres = ...metres

7) Calculate the volume of the following blocks, when given:

a. length = 75 cm, width = 3 m, height = 6 cm = = = V = ...m^3
b. length = 0.5 cm, width = 1 dm, height = 20 cm = = = V = ...m^3
c. length = 15 cm, width = 2 dm, height = 0.5 m = = = V = ...litres

8) Calculate the volume of water (in m^3) on a field, when given: the length = 150 m, the width = 56 m and the water layer = 70 mm.

9) Calculate the minimum depth of a reservoir, which has: a length of 15 m and a width of 10 m and which has to provide 50 mm water for a field of 175 m long and 95 m wide.

10) Make a graph of the monthly rainfall over a period of 1 year, when given:

Month	Rain (mm/month)
Jan.	42
Feb.	65
Mar.	140
Apr.	120
May	76
June	24
July	6
Aug.	0
Sept.	0
Oct.	10
Nov.	17
Dec.	27

1.7.2 Answers

1)

a. A = 0.5 x b x h = 0.5 x 6 cm x 12 cm = 36 cm^2
b. A = 0.5 x 22 cm x 48 cm = 528 cm^2
c. A = 0.5 x 16 cm x 24 cm = 192 cm^2
d. A = 0.5 x 0.8 m x 0.3 m = 0.12 m^2

2)

a. A = 0.5 x (b + a) x h = 0.5 x (52 cm + 16 cm) x 12 cm = 408 cm^2
b. A = 0.5 x (108 cm + 16 cm) x 20 cm = 1240 cm^2
c. A = 0.5 x (1.8 m + 1.5 m) x 0.3 m = 0.495 m^2

3) $A = 0.5 \times (b + a) \times h = 0.5 \times (1.2\ m + 2.6\ m) \times 1\ m = 1.9\ m^2$

4) $A = 0.5 \times (b + a_1) \times h_1 - 0.5 \times (1.2\ m + 2.32\ m) \times 0.8\ m = 1.408\ m^2$

5) Area of the field in square metres = l (m) x w (m) = 120 m x 85 m = 10 200 m^2

$$\text{Area of the field in hectares} = \frac{\text{area of the field in } m^2}{10\,000} = \frac{10\,200}{10\,000} = 1.02 \text{ ha}$$

6)

a. 1820 m x 25/100 = 455 m
b. 971 cm x 13/100 = 126.23 cm
c. 8000 apples x 83/100 = 6640 apples
d. 18 060 m x 7/1000 = 126.42 m
e. 26 ha x 13/100= 3.38 ha
f. 28 000 m x 1.5/1000 = 42 m

7)

a. V = l x w x h = 0.75 m x 3 m x 0.06 m = 0.135 m^3
b. V = 0.005 m x 0.10 m x 0.20 m = 0.0001 m^3
c. V = 1.5 dm x 2 dm x 5 dm = 15 dm^3 = 15 litres

8) V = l x w x h = 150 m x 56 m x 0.070 m = 588 m^3

9)

Volume of water required on a field: V = length of field (m) x width of field (m) x thickness of water layer (m) = 175 m x 95 m x 0.050 m = 831.25 m^3

Volume of the reservoir: V = 831.25 m^3 = length of reservoir (m) x width of reservoir (m) x depth of reservoir (m)

$$\text{Depth of the reservoir (m)} = \frac{\text{volume of the reservoir } (m^3)}{\text{width of reservoir (m) x length of reservoir (m)}} = \frac{831.25 m^3}{150 m^2} = \text{approx. } 5.54 \text{ m}$$

Graph of monthly rainfall over a period of one year